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Using Data, Communication & Education to Improve Swine Waste Management in the Buffalo River Watershed

S. J. Formica, T. Morris, M. A. Van Eps, T. Kresse, M. Anderson, & J. Giese

Arkansas Department of Environmental Quality (ADEQ)

Introduction

The Buffalo River watershed is home to our country=s first National river and is located in the Ozark Mountains of Northern Arkansas. It is known for its scenic beauty and excellent water quality. During the mid nineties, a watershed scale investigation of confined animal operations was initiated in response to public opposition to expansion of the industry within the basin. The investigation revealed a history of poor swine manure management, and that, in general, problems and solutions associated with swine manure management systems (MMS) were not clearly defined. The ADEQ was awarded a competitive Environmental Protection Agency (EPA) 319 (h) Nonpoint Source Grant to conduct a 5-year study, ABuffalo River Liquid Waste Management System Demonstration Project (Swine Demonstration Project)@ The EPA 319(h) Nonpoint source grants are administered by the Arkansas Soil and Water Conservation Commission (ASWCC). The Swine Demonstration Project was initiated in 1995, and its purpose was to help insure the protection of the Buffalo River by working with the local swine farmers, the swine industry and government agencies to identify and address the problems associated with manure management. The project objectives were to:

- Evaluate the effectiveness of existing Best Management Practices (BMPs), including design, training, and management aspects, by monitoring manure management practices and water quality at cooperating swine farms
- Improve existing BMPs and/or implement new BMPs
- Evaluate changes in the operation & maintenance of the MMS and in the water quality as a result of improved and/or new BMPs implemented at cooperating swine farms

Cooperative efforts between farmers, industry and government agencies resulted in improved manure management in the Buffalo River watershed by family-owned, contracted swine facilities. Water quality data collected near one swine facility indicated that the annual mass of nutrients leaving the facility was significantly reduced. This paper will focus on the approaches used in the Swine Demonstration Project which resulted in swine farmers changing their attitudes toward and improving their manure management practices; a reduction of pollution associated with the manure generated at swine facilities; and better utilization of manure as a fertilizer.

Background

The Buffalo River Watershed and Water Quality

The Swine Demonstration Project was conducted in the Buffalo River watershed (Figure 1). The Buffalo National River was established by Congress in 1972 for the purposes of "conserving and

interpreting an area containing unique scenic and scientific features, and preserving, as a free-flowing stream, an important segment of the Buffalo River" (Buffalo River National Park Service, 1991). In addition, the ADEQ designated the Buffalo River as an Outstanding National Resource Water and a Natural and Scenic Waterway with extraordinary recreation and aesthetic values; the highest rankings given to a stream in the state of Arkansas. The Buffalo River watershed encompasses approximately 347,068 ha of which the National Park Service manages 11% primarily as a riparian corridor along the main Buffalo River, the United States Forest Service manages 26% within the headwaters, the Arkansas Game and Fish Commission manages 3% and private landowners own the remaining 60%. The watershed consists of 73% forestland, 25% agriculture land, 1% urban/barren land, 0.3% water, and 0.7% others (Scott and Udouj, 1999).

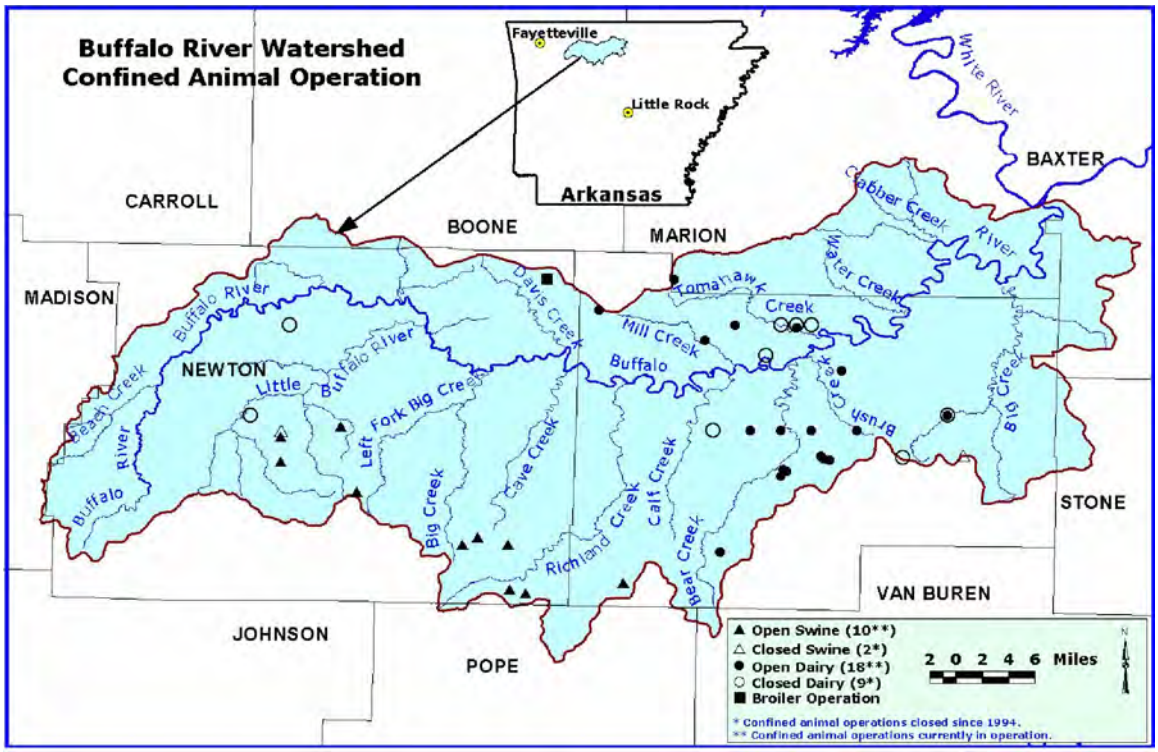

Figure 1. Buffalo River Watershed

Water quality monitoring from 1985 to 1995 by Mott (1997) indicated low but slowly increasing fecal coliform bacteria levels within the main channel of the Buffalo River. Average bacteria levels in the tributaries were found to be twice as high as in the Buffalo River. Nutrient concentrations increased in the middle section of the river and in tributaries that drain into the middle section of the river. Increases in nitrate concentrations directly correlated to areas with greater pasture coverage. Turbidity levels at base-flow conditions were very low, except for the tributaries of Beech, Cecil, and Richland Creeks. Elevated turbidity levels in these streams were attributed to the sandstone and shale geology of the contributing watersheds. Agricultural activity was indicated as the source of elevated fecal coliform and nutrient levels in the Buffalo River tributaries. Overall, the base-flow water quality conditions in the Buffalo River and its

tributaries were found to be excellent and well below state standards (Mott, 1997).

Confined Animal Operations in the Buffalo River Watershed

At the commencement of the Swine Demonstration Project, there were approximately thirty-five confined animal operations in the Buffalo River watershed (Figure 1.) A variety of manure management practices were being implemented at those facilities. Twenty-one of the confined animal operations in the watershed had Liquid Animal Waste Management Systems designed by the Natural Resource Conservation Service (NRCS) of which 11 were swine and 10 were dairy. All of these operations had MMS and plans that were approved by the ADEQ. Initially, the swine operations in the watershed were farrowing operations, in which pigs are raised from birth to 40 lbs before being shipped to a swine finishing facility. The number of sows at these facilities ranged from 250 to 500. During the course of the project, several watershed swine farmers converted to Afarrow-to-wean@operations in which 10 lb weaned pigs were shipped to a separate nursery operation. Subsequently, the number of sows increased to 300 to 550 per facility. Dairy operations in the watershed typically had between 50 to 100 cows in the milking herd. There were also 15 facilities that did not have approved MMS and plans, including one poultry broiler, one swine and 13 dairy operations.

Swine Production and Manure Management

Most facilities in the watershed were small family-owned farms that held contracts to raise swine for companies. The majority of these facilities were built during a period of rapid swine industry growth in the 1980's. The waste or manure (includes manure and waste water) management systems consisted of storing swine manure (includes feces and urine) in earthen containment structures, which typically had two cells, and utilized re-circulated waste water to flush manure from the swine barns. The earthen structures typically consisted of a settling basin, used to remove solids from suspension, and a holding pond, used for solids and wastewater storage. Re-circulated waste water from the holding pond, stored in 300 to 500 gallon concrete flush tanks, was released one or more times a day, to flush manure from shallow concrete gutters, which extend the length of the barns at a 2% grade. Settling basins were generally designed for 45 days of solids storage, and holding ponds were typically designed for a minimum of 120 days storage of manure and waste water. When storage in the settling basins or holding ponds was exhausted, manure and wastewater was applied to pasture as fertilizer for a cover crop. Pastures receiving land-applied manure and wastewater were typically used for grazing cattle or for hay production. Most watershed farmers used liquid manure spreaders and/or irrigation systems for applying manure and wastewater to pasture. Cover crops typically grown by watershed swine farmers were bermuda and fescue grasses.

Project Approaches, Design & Results

A review of swine facility inspections and site visits had revealed that swine manure management problems were common for operations in the watershed. Those involved in the swine industry and manure management included local, watershed landowners; federal & state government workers; and employees of an international industry. It was not surprising that this

group of people, from a variety of employment situations and backgrounds, did not form a consensus (initially) on what the problems were, the causes, or the solutions. The Swine Demonstration Project team, consisting of ADEQ personnel from the Environmental Preservation and Water Divisions, took the approach that it was necessary to start with a comprehensive investigation of the watershed swine production facilities by collecting swine production, swine manure management, and water quality data. Scientific data and information were collected and evaluated so that:

- Swine manure management problems and the extent these problems were affecting water quality were clearly defined and understood by all project participants
- Sound solutions to existing manure management problems could be developed
- Environmental benefits from the implementation of sound manure management practices were documented and understood

Cooperation & Project Partners

By the start of the Swine Demonstration Project, the project team had already developed relationships with the many different entities involved in growing swine and handling manure. The project team recognized that the entities involved in barn design, MMS design, oversight of the design and operation of the MMS, and operation and management of the watershed swine facilities were mostly focused on their particular responsibility. In order to develop lasting solutions to the swine manure management problems in the watershed, all of the players needed to come together to objectively examine and understand each other's relationship to the industry and their concerns. They also needed a forum that would facilitate better communication with each other. The project team found that all of the entities involved in the swine industry were willing to cooperate with each other and participate in the project. Project Partners and their roles are shown in Table 1.

Data Collection & Problem Identification

Data and information related to operation, maintenance, and character of the manure were collected at existing swine facilities. Six of the watershed swine farmers volunteered to participate in the collection of manure management data, which was used to evaluate their MMS. The types of information and data collected included:

1) Routine facility surveys were performed at project farms at approximately two-week intervals to evaluate the operation of the MMS. Areas that were evaluated included a) manure storage structures including integrity, available freeboard and solids accumulation; b) land application of manure and waste water; and c) dead animal management. Routine facility surveys were unannounced and were conducted during both dry and wet weather conditions.
2) Comprehensive sampling of manure storage structures was performed to characterize manure and waste water that was being land-applied to pasture as a fertilizer and to determine the extent and nature of solids and nutrient accumulation.
3) Swine farmer time management was evaluated by logging the amount of time project farmers spent on growing pigs verses operating their MMS.
4) Volumes of manure and wastewater generated at the project farms were estimated to

determine if design storage capacity was sufficient for storage of manure and wastewater during the winter months.

5) Records of the land application of manure and wastewater to pasture were evaluated, which included reviewing volume land-applied, locations of pastures, and soil sampling results of pastures.

Table 1. Participating partners in the Swine Demonstration Project

Project Partner	Partner Role
Watershed Swine Farmers	Local farmers who owned and operated the swine production facilities but grew animals under a contractual arrangement for a company, and who were responsible for swine production and manure management
Newton County Conservation District Board	Community leaders in local conservation practices, who provided local support for the project
Natural Resource Conservation Service	Local representatives provided MMS design and nutrient management plan for watershed swine farmers
Community Member	Represented the community at large and provided input from outside of the swine production circle.
Arkansas Pork Producers Association	Provided input from the swine industry, companies (responsible for barn design and pig production process) who held contracts with the watershed swine farmers, and swine farmers throughout the state
Arkansas Soil & Water Conservation Commission	Provided 319 grant oversight and expertise on BMPs
University of Arkansas, Agronomy Department	Provided applied research expertise
University of Arkansas, Cooperative Extension Service	Provided expertise on BMPs and opportunities to educate farmers
Arkansas Department of Environmental Quality	Implemented and directed project, provided expertise on water quality and BMPs, and provided a local field representative that lived in the watershed

The data collected at the six project farms was used to clearly identify the problems associated with MMS design, operation, and maintenance. Overall, the data revealed that site limitations had not been considered at each swine facility when the MMS had been designed and the MMS were not operated or maintained according to design. Problems observed included:

1) The location of the swine facilities made operation of the MMS difficult. These facilities had been built on hillsides; typically at the beginning of a drainage. Diverting both surface and groundwater from the manure storage structures proved to be a challenge. Also, transporting thousands of gallons of liquid manure over hills, dirt roads and rough terrain tasked the **A**used@ manure spreaders, which constantly required maintenance and repair.

2) The capacity of the manure storage structures was insufficient, because storm water and excessive quantities of fresh water were entering the MMS. Due to the geographic location of these facilities, storm water diversions needed maintenance on a routine basis. Areas where storm water was entering the MMS were identified while visiting the sites during storm events. Many farmers needed additional storm diversions built. Additionally, excessive fresh water usage by the farmers was observed for both pig production and manure management and resulted in manure storage structures becoming filled, prematurely.
3) The manure storage ponds were full of solids, reducing the design storage capacity of the MMS. The farmers were mainly pumping the wastewater from the top of their holding ponds for land application, which resulted in an accumulation of compacted solids in the MMS. Winter storage, needed to hold the manure and wastewater generated during inclement weather, was lost to solids that had accumulated over the years.
4) The equipment for handling the manure and wastewater at project swine facilities was not appropriately sized to handle solids or the volumes of wastewater being generated at the farms. Some farmers only had a 1000-gallon manure spreader to handle volumes estimated to sometimes exceed over 500,000 gallons, annually. Also, the tractor-powered agitators that were being utilized could not sufficiently suspend the settled solids to facilitate removal and land application. In addition, their pumps were not appropriate for managing high solids content slurries.
5) Access to the storage ponds by manure handling equipment was limited (again, this was due to geographic location.) Additionally, poor roads with inadequate drainage prevented equipment access to manure storage ponds during the optimum time for fertilizing pasture.
6) The actual man-hours spent operating swine facilities exceeded projected labor requirements. The contract growers were responsible for the pig production, operating & maintaining a MMS, and handling dead animals. For most project farms, the amount of time spent performing these tasks exceeded the original projection for their facilities at the time the data was collected.
7) The project swine farmers were not fully utilizing the value of their manure. Most of the project farmers were land applying their manure and wastewater on the pasture nearest to their facility. Also, most project farmers were not able to remove significant amounts of solids from their storage structures. So nitrogen was being lost to the atmosphere, while phosphorus was accumulating in their storage structures.

Overall, the data showed that operating a MMS according to design was a challenge to farmers in the Buffalo River watershed.

Water quality data was used as an environmental indicator to determine if significant amounts of nutrients were leaving swine facilities. Continuous monitoring stations were installed upstream and downstream of a project farm to determine nutrient loads leaving that particular swine facility. Both base and storm flows were monitored before and after the implementation of BMPs. Also, groundwater monitoring wells were installed upstream and downstream of four project swine facilities. The results of the water quality monitoring prior to the implementation of BMPs indicated the following:

1) A 300 sow farrow-to-wean swine facility can contribute nutrients (estimated 3000 lbs total

nitrogen (TN) and 400 lbs total phosphorus (TP), annually) and other contaminants to surface water when sound manure management practices are not implemented, turning a valuable resource into pollutants. Improved management practices, which maximized the fertilizer value of manure needed to be implemented, in order to reduce pollutant loads leaving swine facilities. 2) The swine farms in the Buffalo River watershed were primarily impacting surface water. 3) The local geologic setting plays an important role in the integrity of the earthen manure storage structures and, in this case, helped limit the impacts to ground water quality.

Project Communication & Education Tools

The project team recognized that the project partners needed to be informed of the data and MMS evaluations; understand pig production from both a contract farmer and industry perspective; and be involved in the development of solutions to the identified problems. The project team used several mechanisms to inform and educate the project partners.

First, a Task Force Committee was formed with representation from all the project partners. The project team held sit-down meetings, approximately, every six months. The meetings were designed for presenting data and discussing results. The project team used these meetings to obtain input from all partners on both project design and the development of solutions. Also, the project team would periodically take the Task Force Committee to the project swine farms, so the partners could experience the manure management problems and the pig production process first-hand. Both the sit-down meetings and site visits allowed for the project partners to get to know each other, as well as strengthen the relationship of the entire group. The activities of the Task Force Committee resulted in the following: 1) partnerships were formed and strengthened between project partners; 2) project partners increased their knowledge of MMS and pig production, and what it took for the local contract farmers to operate their swine facilities; 3) project partners gained a better understanding of the individual roles concerning the design, operation and oversight of the farms; and 4) solutions to identified problems were developed and agreed upon by project partners.

Second, the project team periodically brought the watershed swine farmers together for technical transfer workshops and hands-on field demonstrations of BMPs. The local Conservation District and the NRCS personnel participated in both of these activities. At the technical transfer workshops, project data, proposed solutions, and economic information were presented to the watershed farmers. These meetings gave the farmers an opportunity to voice their concerns and give their input on proposed solutions. The field demonstrations gave swine farmers the opportunity to observe real solutions working at a local farm. One field demonstration involved a waste pump-out service demonstrating the removal and land application of accumulated solids from swine storage structures at one of the project farms. These types of activities designed for the farmers resulted in: 1) strengthened partnerships between the local farmers and the government agencies; 2) the opportunity for farmers to share their manure management problems and successes with each other; 3) the opportunity for farmers to express their environmental concerns and help develop practical and economical solutions; and 4) improved farmers knowledge of the operation and maintenance of their MMS, and the fact that they were able to implement this knowledge at their farms.

Third, throughout the project, the project team had frequent interactions with the watershed farmers. The project team worked directly with the project farmers when collecting manure management data and implementing BMPs at their facilities. During the BMP implementation phase, the project field person provided Aone-on-one@assistance to individual farmers on the operation and maintenance of their MMS. These activities resulted in farmers learning how to properly operate and maintain their MMS and implement their nutrient management plan. Additionally, trusting relationships were formed between the watershed swine farmers and the project team. The relationships that formed between the farmers and the project team were critical to the success of the project, in that those relationships allowed the project staff to work closely and openly with the participating farmers.

Fourth, throughout the project, there were special presentations of the data and site visits given to individual partners as needed or requested. Specifically, the Arkansas Pork Producers Association (APPA) requested several presentations to their board as well as farm site visits for industry representatives. Also, special presentations and/or farm site visits were given to ADEQ, ASWCC, and EPA. These activities helped to provide additional information and education needed for individual partners to receive support from their organization in assisting with development and implementation of solutions.

Results of Successful Communication and Education

The collection of scientific data and information, using that data and information to identify problems, and coordinating with all project partners resulted in the development and implementation of solutions to the problems at watershed swine facilities. The solutions made economical sense to the swine farmers, while achieving the goal of the project. With assistance from government agencies and the industry, the watershed swine farmers implemented structural BMPs, as well as BMPs that addressed operation and maintenance of the swine facilities. Table 2 indicates the BMPs that were implemented on project farms.

Table 2. BMPs implemented at watershed swine facilities

Structural BMPs	Operation and Maintenance BMPs
Surface water diversions were constructed or improved	Minimization of fresh water usage
Accumulated manure solids were removed from settling basins and holding ponds	Hiring waste contractor with appropriate equipment to handle manure solids annually
Waste storage ponds were reconditioned	Acquiring appropriately sized manure handling equipment for the amount of manure generated
Staff gauges were installed in holding ponds	Improved fertilizer utilization by considering timing of manure application, soil conditions, and removing manure solids each year
Waste collection systems were repaired	
Roads to manure storage structures were improved	

Through open and frequent communication and through opportunities to educate all project partners, the results of the Swine Demonstration Project also helped to improve manure management outside of the watershed. After participating in this project, the response and actions of the APPA affected swine manure management not only in the watershed, but statewide and nationally. First, the APPA contributed to a watershed cost-share program for the removal of accumulated manure solids from storage structures. Eleven watershed farmers participated in this program and had manure solids removed and land-applied to pasture. The contents of the manure ponds were sampled and characterized, and site-specific nutrient application plans were developed for the pond clean-outs. Second, the APPA contributed funding for the ADEQ to perform a statewide study, which evaluated solids accumulation in swine manure holding ponds. From this study another statewide project was initiated, in which swine farmers can obtain technical assistance with the removal of accumulated solids. Third, the APPA initiated what is now called the **A**nternal Audit Program.@Historically, the ADEQ performed inspections of swine facilities every one to three years, or if a complaint was lodged. The Internal Audit Program utilizes the field representative of the contracting company, who traditionally only assisted with pig production, to evaluate the MMS monthly. If the field representative finds repeat problems at a facility, then a follow-up ADEQ inspection is requested. One of the swine companies operating in Arkansas has now implemented this program on a nation-wide basis.

Continued Data Collection & Management Improvements

Both swine manure management and water quality data were collected after BMPs were implemented at swine facilities in the watershed, and this data was presented to project partners. The swine manure management data indicated that farmers had improved the operation and maintenance of the MMS. Also, water quality data indicated that the improved manure management resulted in fewer nutrients leaving the farm site from surface runoff. Water quality data collected near one swine facility was evaluated and preliminary estimates indicated that the annual mass of nutrients leaving the facility was reduced by 67% for TN and 81% for TP. Preliminary estimates also indicated that flow-weighted concentrations of nutrients, prior to and following BMP implementation, decreased 85% and 91% for TN and TP, respectively. Better

implementation of the farm nutrient management plan had many environmental benefits. By utilizing all of the manure solids generated at the facility, annual nitrogen loss to the atmosphere decreased while nitrogen available for fertilizer increased. Additionally, a better ratio of nitrogen to phosphorus is maintained in the liquid waste (Van Eps, et al.), decreasing the over-application of phosphorus to soil, which is common with the application of animal manures. Therefore, better manure management resulted in increased protection of water, air, and soil.

Although the project team has been successful in meeting the goal the project, the need to evaluate and improve swine manure management persists. The project team continues to work with swine farmers both within the watershed and statewide to improve the operation and maintenance of MMS. Currently, the project team is implementing and evaluating alternative MMS operating schemes to further reduce, the amount of time spent and amount of nutrients lost to the environment associated with the management of these systems. The premise of the alternative operating scheme is to handle the liquid and solid components contained in the manure holding ponds, independently. This approach better utilizes the nutrients contained in the waste water, reduces the potential for pond overflow, and employs methods of management that do not deviate too far from those historically utilized by swine farmers. The project team will also be providing data and information from this project to assist in the possible development of siting criteria and minimum design requirements to reduce potential problems at facilities built in the future.

Project Success Summary

Overall, the goal of this project was accomplished. Local swine farmers, industry, and government agencies worked together voluntarily to solve a serious watershed threat. All of the partners in the project cooperated to evaluate the data generated on the MMS and to develop BMPs for existing systems. New and/or improved BMPs were installed by extending cost-share programs and working one-on-one with local swine farmers to insure that all aspects of the MMS were understood. Swine farmers in the Buffalo River watershed have successfully changed their manure management practices, and are reaping the benefits of efficiently utilizing their manure as a fertilizer, while minimizing the impacts of their facilities on the environment. In addition to the success at the local watershed level, this project has been effective at addressing manure management issues at a state and national level. All of the partners participating in the project received an EPA Region 6 Partnerships for Environmental Excellence Award in 1998, which was presented during a ceremony at the Arkansas State Capital. The award acknowledged the contribution of each partner in cooperating to solve complex environmental problems.

Summary of Approaches Used for Success

Some of the approaches that were used throughout the course of this project that contributed to its success include: 1) participation was voluntary; 2) Aone-on-one@assistance was provided to farmers throughout the project; 3) the project team had a field representative that lived locally in the watershed; 4) the data and identified problems were presented to all of the project partners with an emphasis placed on problem solving; 5) the project team worked with all the project partners to develop solutions; 6) the project team considered economics when developing

solutions; 7) the project team fashioned solutions to fit the existing MMS; 8) project funds were used to provide cost-share assistance to farmers for implementing BMPs; 9) a positive focus was maintained with project partners; and 10) the project team collected data to identify and understand problems, determine solutions and to verify that implemented BMPs were working.

Summary of Lessons Learned & Advice for Future Successful Projects

As with any undertaking, there is usually a discovery at some point during the process that there are better ways of accomplishing the task. This realization often occurs well into or near the completion of the undertaking. Some lessons learned by the project team during the course of the Swine Demonstration Project and subsequent advice include the following: 1) seek cooperation & input early from your partners, especially, as you are developing and designing your project; 2) use all the time and resources needed to build partnerships, because strong partnerships based on trust and cooperation are essential to communication and project success; 3) learn all you can and educate project partners about all aspects of the industry you are working with, especially, the entities that are responsible for developing BMPs; 4) take the time to collect the data you need to make sound technical & planning decisions, and to educate project partners; and 5) set up a system to evaluate data as it is collected, or you will be inundated with data needing to be evaluated at the end of your project.

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